DOCUMENT RESUME

ED 195 263 IR 009 030

AUTHOR Reigeluth, Charles M.
TITLE Meaningfulness and Instruction: Relating What Is Being Learned to What a Student Knows.
INSTITUTION Syracuse Univ., N.Y. School of Education.
REPORT NO IDD&E-WP-1
PUB DATE Mar 80
NOTE 36p.

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Epistemology; *Instructional Design; *Instructional Improvement; *Learning Processes; *Learning Theories; *Prior Learning; Teaching Methods

ABSTRACT

Making new knowledge meaningful by relating it to prior knowledge is an important aspect of instructional design theory. Six kinds of prior knowledge can optimize the acquisition, organization, and retrieval of new knowledge: (1) superordinate, which includes and subsumes the idea to be learned; (2) coordinate, which is closely related to the new knowledge; (3) subordinate, which is an instance or example of the new idea; (4) arbitrary, which has no inherent relationship to the new knowledge; (5) analogic, which is outside the content area of the new knowledge but is similar; and (6) cognitive strategies, which are content-free skills used to facilitate learning and remembering. Instructional strategies for making use of prior knowledge include subsumptive sequencing (superordinate knowledge taught first); synthesizers (which show relationships among concepts, principles, or procedures); instances (examples of a concept, principle, or procedure); mnemonics (arbitrary memory aids provided in, or activated by, the instruction); analogies (which relate new knowledge to highly similar knowledge outside of the content area); and cognitive strategy activators (which embed strategy within instruction or tell the learner to use it). (BK)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED195263

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

MEANINGFULNESS AND INSTRUCTION: RELATING WHAT IS BEING LEARNED TO WHAT A STUDENT KNOWS

by

Charles M. Reigeluth

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Charles M. Reigeluth

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

IR009030

This report is a working paper intended for prepublication distribution. The reader's comments are solicited and should be conveyed directly to the author(s).

IDD&E Working Papers are distributed free to faculty members and students in the Instructional Design, Development and Evaluation Program at Syracuse University and to a limited number of organizations in the field of Instruction.

Additional copies are available at cost from the editor. If you would like to subscribe regularly to the IDD&E Working Papers at cost, please notify the editor.

IDD&E Working Papers
Instructional Design, Development, & Evaluation Program
Division of Educational Development and Administrative Studies
School of Education
Syracuse University

Charles M. Reigeluth, Editor
Valerie Junod, Production Editor
116 Huntington Hall
Syracuse University
Syracuse, NY 13210

Any comprehensive theory of instruction must be concerned with how to optimize the acquisition, organization, and retrieval of new knowledge. Since the time of Ausubel, it has been recognized that making new knowledge meaningful to the learner is important for optimizing acquisition, organization and retrieval; and more recently it has become clear that this is done primarily by relating the new knowledge to what a student already knows. Because Ausubel's ideas so dominated cognitive science for so long, many people have come to associate "making new knowledge meaningful" with relating it to superordinate knowledge (that the learner already possesses) within the content area of immediate interest. But this is only one way of making learning meaningful.

Occasionally Ausubel's advance organizers accomplish the same purpose by relating new knowledge to parallel knowledge (that the learner already possesses) outside of the content area of immediate interest. Another largely overlooked way to make new knowledge meaningful is by relating it to real (specific) sensory events or actions stored in what we refer to as the "experiential" data base, which stores what Merrill refers to as "instances" or "referents," and which is similar to what Lindsay and Norman (1977) refer to as the "sensori-motor data base." (This is probably the major way that new knowledge is made meaningful during the early years of human cognitive development.)

The purposes of this paper are (1) to describe six kinds of prior knowledge that can be used to facilitate the acquisition, organization, and retrieval of new knowledge and (2) to describe a variety of instructional strategies that can be used to help optimize the learner's use of these six kinds of prior knowledge.

Six Kinds of Prior Knowledge

The following are six kinds of prior knowledge that can be used to facilitate the acquisition, organization, and retrieval of new knowledge: (1) a superordinate idea, which serves as "ideational scaffolding" for new knowledge, (2) a coordinate idea, which serves an associative, comparative, or contrastive function, (3) a subordinate idea or specific instances, which relate the new knowledge to the learner's experiential data base, (4) arbitrary meaningful knowledge, to which rote (non-meaningful) knowledge can be related in order to facilitate retention, (5) an analogic idea, which relates new (potentially meaningful) knowledge to highly similar knowledge that is external to the content of interest, and (6) a cognitive strategy, which is valuable for appropriate cognitive processing of the new knowledge. These six kinds of knowledge are each described below, followed by a section on instructional strategies for using each of these six kinds of prior student knowledge.

Superordinate Knowledge

A superordinate idea is one which is more inclusive and/or more simple than the idea that is to be learned and which also subsumes the idea that is to be learned. In Figure 1, if "variable resistor" is the concept that is to be learned, then "wire-wound resistor" is the superordinate idea.

If the knowledge of interest is a concept[1], then the superordinate concept is more inclusive (i.e., it has more specific examples and more kinds of examples), and it is more simple (i.e., it has fewer "critical" characteristics--characteristis that are common across all of its examples).

For example, "dog" is superordinate to "collie." If the knowledge of interest is a principle[2], then the superordinate principle is more inclusive (i.e., it has greater breadth of applicability--more specific instances, or applications), and it is more simple (i.e., it involves fewer variables and its variables tend to be more general concepts--more inclusive and more simple). For example, the law of supply and demand is superordinate to the principle of profit maximization. (Also, see Figure 2 for an additional example.) If the knowledge of interest is a procedure[3] (or skill), then the superordinate procedure or skill is more simple (i.e., it entails fewer steps or operations and those steps or operations tend to be more fundamental). For example, the procedure for subtraction without borrowing is superordinate to the procedure for subtraction with borrowing. In all three cases the superordinate idea subsumes the idea that is to be learned. In other words, the idea to be learned can be viewed as a more detailed or complex case of the superordinate idea.

Ausubel (1963, 1964) pioneered the notion that a superordinate idea already known by the learner provides "ideational scaffolding" for what is being learned, thereby making it meaningful; and Mayer's (1976, 1977, 1979) assimilation encoding theory extends this notion with the process of "activation of an assimilative set." Although Ausubel's primary concern is making use of superordinate ideas to build stable cognitive structures (i.e., the organization of new knowledge), they also serve to facilitate acquisition by relating the new idea to a similar (more general) idea that is already familiar to the learner (Mayer, 1979). Knowing what a wire-wound resistor is takes a learner "half way there" to understanding what

a variable resistor is (see Figure 1). Finally, superordinate ideas serve to facilitate retrieval by creating a strong link to the new idea within a learner's memory (E. Gagne, 1979). (This is one of many cases where a single instructional process can implement more than one principle of learning and/or cognition.) It should be noted that, unlike Ausubel, we do not believe that a superordinate idea is or should be more abstract than what is being learned, either for facilitating retrieval, for facilitating acquisition, or for building stable cognitive structures.

To be most useful, the superordinate idea selected should be that one which is closest to the idea that is being learned (e.g., dog, rather than mammal or vertebrate, for relating to collie).

Insert Figures 1 and 2 about here

Coordinate Knowledge

A coordinate idea is one which is on the same level as the idea that is to be learned. It must also be closely related to the idea that is to be learned. To be more precise, its examples must be mutually exclusive of the new idea's examples, and it must have the same superordinate idea. In Figure 1, fixed, tapped, and sliding contact resistors are all coordinate to "variable resistor."

If the knowledge of interest is a concept, then a coordinate concept is a mutually exclusive concept whose closest superordinate concept is the same. For example, beagle is mutually exclusive of collie (i.e., no beagles are

collies and no collies are beagles), and both are dogs. If the knowledge of interest is a principle, then a coordinate principle is a mutually exclusive principle whose closest superordinate principle is the same. For example, the principle of utility maximization is mutually exclusive of the principle of profit maximization (i.e., no instances of one are instances of the other, and vice versa) and both are subordinate to the law of supply and demand. (See Figure 2 for an additional example.) If the knowledge of interest is a procedure (or skill or technique), then a coordinate procedure is a mutually exclusive procedure that is also a more complex version of the same superordinate (more simple) procedure. For example, the procedure for subtraction of fractions without borrowing is mutually exclusive of the procedure for subtraction of whole numbers with borrowing (i.e., no instances of one are instances of the other, and vice versa), and both are subordinate to the procedure for subtraction of whole numbers without borrowing (i.e., both are more complex iterations of the latter more fundamental procedure). In all cases, two coordinate ideas can be viewed as more detailed or complex cases of the same superordinate idea.

Relating "what is to be learned" to a coordinate idea that the learner already knows should facilitate acquisition by helping the learner to compare and contrast the new idea to a highly similar one that is known. In learning what a variable resistor is (see Figure 1), it is helpful for the learner to know that it is not a sliding contact resistor--that it is different in certain ways--but that it is also similar in certain ways. Relating a new idea to a known coordinate idea should also help the learner to organize memory in a stable way (i.e., to build stable cognitive structures) because the relationships among related ideas will be learned cor-

rectly from the beginning and will therefore not require subsequent reorganization of memory. Finally, it should serve to facilitate retrieval by creating additional links to the new idea within the learner's memory (E. Gagne, 1979).

To be most useful, the coordinate idea should be as similar as possible to the idea that is being learned.

The Experiential Data Base and Subordinate Knowledge

The "experiential" data base (similar to the sensori-motor data base--see Lindsay & Norman, 1977, pp. 390-1, 510) is a person's memory of specific objects, events, or ideas (which are referred to as instances in instructional theory). Instances are the equivalent of what is on the lower or terminal end of the "isa" relation in Lindsay and Norman, 1977. In a discussion of the circularity of dictionary definitions, Lindsay and Norman (1977) say that, in the human information processing system, "circularity of the information is avoided by providing reference to real sensory events and real actions." (p. 390) Instructional Science has long recognized the value of such an "experiential" data base in its prescriptions for providing instances and instance practice to extend the experiential data base (Gropper, 1974; Markle & Tiemann, 1969; Merrill & Wood, 1975; Merrill, Reigeluth & Faust, 1979). But it may not always be necessary to extend the experiential data base in order for a learner to learn new ideas at the application level (or use-a-generality level) of knowledge, because the learner may already have sufficient experiential data, either in the form of isolated instances or in the form of subordinate knowledge.

A subordinate idea is one for which the idea that is to be learned is a superordinate idea. There are two major kinds of subordinate ideas (Reigeluth, Merrill, & Bunderson, 1978): those which are kinds of the idea to be learned, and those which are parts of the idea to be learned. These correspond to the "class" and "has-as-parts" cognitive relationships in Lindsay and Norman (1977). For example, potentiometer and rheostat are two kinds-subordinate concepts for variable resistor (see Figure 1 above), while wire and sliding contact would be two parts-subordinate concepts for variable resistor.

For purposes of relating a new idea to a learner's experiential data base, the kinds-subordinate idea is the only one of interest. All instances of a kinds-subordinate idea are also instances of the idea to which it is subordinate (e.g., all rheostats are variable resistors). Therefore, if a learner already knows one or more kinds-subordinate ideas, then the idea tha is to be learned can be related to the learner's experiential data base much more economically and powerfully by telling the learner that all instances of the kinds-subordinate idea are also instances of the idea that is to be learned, rather than by actually presenting instances of the kinds-subordinat idea. Of course, if any of the kinds-subordinate ideas are unfamiliar to th learner, then instances of those types must be presented. If you take one instance from each of the full set of kinds-subordinate ideas, then you have what Markle and Tiemann (1969) refer to as a "minimum critical subset" of instances. For the application level of knowledge, acquisition is greatly enhanced by presenting such a full range of instances.

Whether by means of providing new instances, by means of activating familiar instances, or by means of relating what is to be learned to a known kinds-subordinate idea, it is important for acquisition and retrieval that

new knowledge be related to a learner's experiential data base. It is important for acquisition because at the application level of knowledge the learner must learn how to apply a generality to instances (which is clearly difficult to learn to do if there are no instances available), and at the remember-paraphrase level (vs. the remember-verbatim level) of knowledge (and its related level of cognitive processing) a reference example can facilitate visualization for imaginal encoding. Relating new knowledge to the experiential data base is also important for retrieval because a valuable link is created to the new knowledge from the experiential data base. Finally, it is also important for the organization of memory that new knowledge be related to subordinate ideas (both kinds and parts), so that the new knowledge will be integrated into stable cognitive structures by subsuming already-mastered lower-order ideas. In this way the new knowledge will serve as the means for classifying or regrouping prior knowledge.

It should be noted that superordinate and coordinate ideas are also linked to the experiential data base. However, the instances of coordinate ideas are never instances of the new idea, and instances of the superordinate idea are not always instances of the new idea. Hence, the utility of those instances is greatly reduced, except that instances of coordinate ideas can serve a useful comparative and contrastive function, as was mentioned above.

Arbitrary Meaningful Knowledge

Arbitrary meaningful knowledge is knowledge which has no inherent relationship to the new knowledge (i.e., any relationship that may exist is

not inherent in the semantic structure of the knowledge). This kind of prior knowledge is useful for memorization of non-meaningful knowledge (i.e., the remember level), wherein various kinds of meaningful (prior) knowledge can be used for mnemonic purposes: peg words (e.g., one-bun, two-shoe, etc.), familiar places, and associations. (See Dansereau, 1978, pp 5-6; and Lindsay & Norman, 1977, pp 359-364, for examples.)

Lindsay and Norman (1977) observe that "the problem in learning new [remember-level] information is not in getting the information into memory; it is in making sure that it will be found later on, when it is needed." (p 337) The above-described kinds of "arbitrary" prior knowledge can be used to create links which, although arbitrary, can greatly facilitate retrieval--finding the new knowledge later on when it is needed.

Analogic Knowledge

An analogic idea is similar to a coordinate idea except that it is outside of the content area of interest. It has the following relationships to the idea that is to be learned: it has the same superordinate idea (which by its nature is broader than the content area of interest), it is on the same general level, it has important similarities, and its instances are mutually exclusive of the new idea's instances.

If the knowledge of interest is a concept, then the analogic concept is one outside of the content area of interest that has important similarities with the concept that is to be learned. For example, if electronics is the content area of interest, then "valve" in a water pipe is outside of the content area but has important similarities with the concept "resistor"

in an electrical circuit. If the knowledge of interest is a principle, then the analogic principle is one that is outside of the content area of interest but has important similarities with the principle to be learned. For example, if electronics is the content area of interest, then the principle that "closing a water valve will cause the flow of water to decrease (assuming the water pressure remains constant)" is outside of the content area but has important similiarities with the principle that "increasing the resistance in a circuit will cause the current to decrease (assuming the voltage remains constant)." If the knowledge of interest is a procedure, then the analogic procedure is also one that is outside of the content area but has important similarities with the procedure to be learned. For example, if mathematics is the content area of interest, then the procedure for taking objects off of a two-armed scale in such a way that the scale always remains in balance is outside of the content area but has important similarities with the procedure for solving an equation.

Relating what is to be learned to an analogic idea that the learner already knows should facilitate acquisition by helping the learner to compare the new idea to a highly similar one that is known. It also helps the learner to interrelate separate cognitive structures, which should facilitate both a more stable organization of memory and the building of content-free skills and knowledge. For example, the learner will learn that there is a superordinate, content-free idea called "resistance," which can be manifested in many different content areas. This should improve the student's ability to transfer knowledge to new applications, to solve problems better, and even to use analogic reasoning as a powerful

learning and thinking tool (see below). Such interrelations among cognitive structures should also facilitate retrieval of the new knowledge through the provision of additional links (E. Gagne, 1979).

To be most useful, the analogy should be as similar as possible to the idea that is to be learned. If the differences are greater than the similarities, then the analogy may be more confusing than helpful.

Cognitive Strategies

A cognitive strategy (R. Gagne, 1977; Rigney, 1978) is a content-free skill (or processing routine) that a person can use to facilitate the acquisition of knowledge (i.e., learning skills) and to facilitiate the organization and retrieval of knowledge already acquired (i.e., remembering skills). (There are also cognitive strategies to facilitate manipulation of knowledge already acquired, i.e., thinking skills, but they are not of relevance to this paper.) A cognitive strategy is a procedure (or processing routine or algorithm)--that is, it is an ordered series of mental steps that are performed to achieve a prespecified goal.

With respect to acquisition, cognitive strategies (or learning skills in this case) include (1) primary strategies, which are applied to the new knowledge, such as skills for identifying important, difficult, and unfamiliar material, and (2) support strategies, which allow the primary strategies to operate effectively and efficiently, such as skills for concentrating in the presence of distractions, fatigue, and the like (Dansereau, 1978). Primary strategies also include elaboration skills, by which "learners use a symbolic construction to add meaning to information they

must learn" (Weinstein, 1978). Elaboration skills include such activities as forming a mental image, paraphrasing, drawing inferences, and relating material to previous knowledge. The use of analogies would fall into this category of cognitive strategies.

With respect to both organization and retrieval, cognitive strategies (or memory skills in this case) include doing a variety of things during acquisition: forcing greater depth--or spread--of processing (e.g., by paraphrasing), creating additional links within one's memory (e.g., by relating the new knowledge to previous knowledge), creating all important links among ideas within one's memory (e.g., by taxonomizing), forcing dual encoding (e.g., by creating images, and using various other mnemonic techniques (e.g., the peg word method). (See e.g., Craik & Tulving, 1975; Dansereau, 1978; Lindsay & Norman, 1977; Rigney, 1978; Weinstein, 1978.) It is also likely that memory skills include activities that can be done after acquisition: activities to improve retention (e.g., by refreshing memory) and activities to find (or reconstruct) information at the time of retrieval.

Cognitive strategies can clearly help a learner to better acquire, organize, and retrieve new knowledge, especially in situations where instruction is poorly designed.

Summary

We have described six kinds of knowledge that can be used to facilitate the acquisition, organization, and retrieval of new knowledge: (1) a superordinate idea, (2) a coordinate idea, (3) a subordinate idea or specific instances, (4) arbitrary meaningful knowledge, (5) an analogic idea, and

(6) a cognitive strategy. In the next section of this paper we will describe some instructional strategies that an instructional designer or teacher can use to help optimize the learner's use of these six kinds of prior knowledge to acquire, organize, and retrieve new knowledge.

Instructional Strategies

Given that the above-described six kinds of prior knowledge can be used to greatly facilitate acquisition, storage, and retrieval of new knowledge, the models and theories of instruction should prescribe optimal strategies for making use of these six kinds of prior knowledge. Of course, any given learner may not already possess all six kinds of knowledge. This possibility must also be taken into account by models and theories of instruction.

Several investigators have argued that Instructional Science is a young discipline that has generated much piecemeal knowledge about methods for optimizing desired instructional outcomes, and that what is needed most at this point in the development of Instructional Science is an integrative, multi-perspectived, building of a common knowledge base (Gropper, in press; Reigeluth, in press). Two concerted, highly systematic attempts have been initiated to integrate knowledge from all theoretical perspectives (e.g., behavioral, cognitive, and humanistic) and all related disciplines (e.g., learning theory, cognitive theory, communication theory, motivation theory, and epistemology). (See Reigeluth, in press.) These two, complementary (non-overlapping) instructional theories--the Elaboration Theory of Instruction and the Component Display Theory--presently include strategies for utilizing four of the six kinds of prior knowledge described above. And work is currently underway to extend those theories to include strategies for utilizing the other two kinds. (It should be noted that these two theories also include many important strategy components in addition to

those that are intended to relate new knowledge to prior knowledge.)

Below is a description of several kinds of instructional strategies for making use of the six kinds of prior knowledge described above.

Subsumptive Sequencing

A subsumptive sequence is simply one in which superordinate knowledge is taught first--no idea is taught before its superordinate idea has been taught (unless it is already known). In this manner superordinate knowledge will always be prior knowledge, so it will always be possible to relate new knowledge to superordinate knowledge. Subsumptive sequencing does not explicitly relate the two--it merely makes it possible to relate the two. A subsumptive sequence is one way of implementing Norman's (1972, 1973) notion of "web learning" and Bruner's (1960) notion of a "spiral curriculum").

It is important to note that the Elaboration Theory's prescription for a subsumptive sequence differs in several important ways from Ausubel's. First, as was mentioned above, we believe that the subsumer does not need to be, and in fact should not be, more abstract than the new idea. "Dog" is no more abstract than "collie." The law of supply and demand is no more abstract than the principle of profit maximization. And the procedure for subtraction without borrowing is no more abstract than the procedure for subtraction with borrowing. Neither should the way in which it is presented be more abstract. Rather than presenting a generality alone (which is abstract by nature), instruction in the superordinate concept should include examples showing the application of the generality to specific instances and practice in applying the generality to new instances as well as the

generality. (This prescription is from the Component Display Theory--see e.g., Merrill, in press; and Merrill, Reigeluth, & Faust, 1979). A second difference from Ausubel's subsumptive sequence is that the Elaboration Theory provides precise guidelines as to how to create a subsumptive sequence (e.g., see Reigeluth, Merrill, Wilson, & Spiller, 1978; Reigeluth & Rodgers, 1980). A third difference is that some advance organizers summarize the content that is to be learned rather than epitomizing it (see Reigeluth, 1979).

Synthesizers

A synthesizer is a strategy component that shows relationships among concepts, principles, or procedures--it shows the logical structure of knowledge in an attempt to create an isomorphic psychological structure (Ausubel, 1964). Synthesizers may be a variety of types. They may show superordinate, coordinate, and subordinate relationships among ideas, or they may show linear or branching chains of "change relationships" (i.e., principles) in the form of theoretical models, or they may show linear or branching chains of "purposive actions" (i.e., procedures) in the form of procedural models or procedural hierarchies (which are different from learning hierarchies). Hence, this strategy component can make explicit the relationships between a new idea and its superordinate, coordinate, and subordinate ideas. The Elaboration Theory calls for presenting (1) a simplified version of the synthesizer for a lesson before the lesson, and (2) a complete version of the synthesizer for a lesson after the lesson.

Figure 1 shows a kinds-conceptual synthesizer, which portrays "kinds-ordinate" (superordinate, subordinate, and coordinate) relationships among

concepts. For more examples of synthesizers (also referred to as subject matter structures), see Reigeluth, Merrill, and Bunderson (1978), Reigeluth, Merrill, Wilson, & Spiller (1978) and Reigeluth, Merrill, Wilson, & Spiller (in press).

Instances

Instances are specific cases to which a generality can be applied. They may be examples of a concept, applications of a procedure, or applications of a principle. An instance may be explained to the student (with respect to how the generality applies to it), which is referred to as an example; or the student may be asked to apply the generality to it on his own, which is referred to as practice, or more precisely as "instance practice." Also nonexamples are instances, only they are instances of a coordinate idea (usually). Hence, an instance may be an example, a nonexample, or a practice item (see Figure 3 for examples of each). Either way, since all three kinds of instances are specific cases, they are stored in a person's experiential data base.

Insert Figure 3 about here

The Component Display Theory calls for the presentation of all three kinds of instances along with each generality. Examples and practice with feedback serve to provide links between a generality in semantic memory and instances (of that generality) in the experiential data base. Also, "matched nonexamples--nonexamples that are as similar as possible to examples--help the learner to compare and contrast the new idea with a highly similar

coordinate idea. For more information about instances and how they can be used to facilitate different levels of cognitive processing (which are appropriate for learning new knowledge at different levels of behavior) see Merrill (in press); Merrill, Reigeluth, and Faust (1979); and Merrill and Tennyson (1977).

Mnemonics

Mnemonics are simply arbitrary memory aids of various kinds that are provided in, or activated by, the instruction. Some mnemonics are totally unrelated to prior knowledge of the learner, such as rhymes (e.g., Thirty days have September ...). However, other kinds of mnemonics serve to facilitate memory by arbitrarily relating the new knowledge to meaningful knowledge that the learner already has. Such mnemonics include the method of places, whereby items on a list are associated by imagery with geographical places along a familiar route, the method of key words (or peg words), whereby each of the items on a list is associated by imagery with such key words as bun (one), shoe (two), tree (three), etc., the story method, whereby each of the items is associated in a fairly natural (non-arbitrary) way with aspects of a story that is invented to facilitate such associations, and the first letter method, whereby the first letter of each item is combined with the other first letters to form a meaningful word or phrase (such as Every Good Boy Does Fine to remember the order of the notes on the scale--EGBDF). For examples of each of these kinds of mnemonics, see Dansereau (1978) pp 5-6, and Lindsay and Norman (1977) pp 359-364.

Mnemonics, therefore, represent a valuable instructional strategy for relating rote, or non-meaningful, knowledge (on the remember level) to prior meaningful knowledge. Although the relationship is "arbitrary" (i.e., it is not a semantic relationship), it is still a very powerful way to facilitate retention. Mnemonics have been incorporated as an important part of the Component Display Theory (see Merrill, in press; Merrill, Reigeluth, & Faust, 1979; Merrill & Wood, 1974, 1975).

Analogies

An analogy is a strategy component which serves to make new knowledge familiar by relating it to highly similar knowledge outside of the immediate content area of interest. Ideally, the learner will already be familiar with the analogy. However, if the analogy is unfamiliar to the learner but is relatively easy to learn, then teaching it before teaching the new knowledge will save more student time and effort than it will cost. Analogies should be used most often when the same analogy facilitates the learning of more than one concept, principle, or procedure. For example, in the hydrology-electricity analogy mentioned above, a water valve is analogous to a resistor, a pump is analogous to a power supply, water is analogous to electrons, electromotive force (or voltage) is analogous to water pressure, water flow is analogous to electric current, and the principles specifying change relations among electromotive force (or water pressure), current (or flow), and resistance (or valve closure) are also analogous.

An analogy should be described (either to activate it or to teach it) before the new knowledge is taught, and references to the analogy should be made at various times during the lesson. Also, it is important to point out aspects where the analogy breaks down so as to avoid overgeneralization from the analogy to the new knowledge (e.g., a power supply does not work the same way as a pump works). Occasionally, Ausubel's advance organizer were analogies (coordinate ideas outside of the content area of interest) rather than superordinate ideas (within the content area of interest). Analogies are currently being integrated into the Elaboration Theory. (See Stein, Witham, & Reigeluth, in press, for a more in-depth description.)

Cognitive Strategy Activators

A cognitive strategy can be activated in either of two basic ways (Rigney, 1978): (1) by designing the instruction in such a way that the learner is forced to use it (called an "embedded" strategy), in which case the learner is often unaware that he or she is using it, or (2) by telling the learner to use it (called a "detached" strategy), in which case the learner has to have already learned how to use it. A detached activator tells the learner to use a certain cognitive strategy, such as "Now draw a diagram showing the processes just described," or "Think of an analogy," or "Create an image of what was just described," or "Think up a mnemonic to help you remember this." Detached activators have recently been integrated into the Component Display Theory under the rubric of "conscious cognitive processing" (Merrill, 1979). An embedded activator forces the learner to use a given cognitive strategy and therefore makes the learning considerably easier for the learner. Embedded activators include pictures, diagrams, and mnemonics

(which are already an important part of the Component Display Theory) and analogies (which are being integrated into the Elaboration Theory). Adjunct questions (Rothkopf, 1976) are intended to serve a similar purpose, and they are usually embedded activators (although occasionally they are detached).

Since most learners have not learned how to use most cognitive strategie they must usually be taught before detached activators can be used effectively. However, it is not necessary for all learners to have learned a cognitive strategy in order for its corresponding detached activator to improve the quality of the instruction. In fact, since such an activator is so short a piece of the instruction, it may be cost-effective to include it even it just one student can benefit from it. Cognitive strategy activators are currently being integrated into the Elaboration Theory. For more information on cognitive strategy activators, see Stein, Witham, and Reigeluth (in press).

Summary

Any comprehensive theory of instruction must be concerned with ways to optimize the acquisition, organization, and retrieval of new knowledge. An important concern in this regard is making new knowledge meaningful by relating it to prior knowledge. Although meaningfulness is usually thought of in terms of relating new knowledge to prior superordinate knowledge (as with the advance organizer), there are at least five other kinds of prior knowledge that can facilitate the acquisition, organization, and retrieval of new knowledge: coordinate knowledge, subordinate knowledge or instances, arbitrary knowledge, analogic knowledge, and cognitive strategies.

Hence any theory of instruction that is intended to be at all comprehensive should prescribe strategies for making optimal use of these six kinds of prior knowledge (if they exist as prior knowledge). Such strategies probably include the following: subsumptive sequencing, synthesizers, instances, mnemonics, analogies, and cognitive strategy activators. Mayer (1979) points out that it is not always helpful to use advance organizers. The same may be true of many of the above-described strategies, and an instructional theory should prescribe those strategies accordingly.

Finally, it is important to keep in mind that relating new knowledge to prior knowledge is only one of several important concerns of instructional theories and models. Other kinds of concerns include motivating the learner, focusing his or her attention on important aspects of the instruction, facilitating dual encoding, providing appropriate kinds of information to effect an appropriate level of cognitive processing that will result in the

desired level of student behavior, and providing a variety of other kinds of instructional support (e.g., shaping and systematic review). Each of these other kinds of concerns should be incorporated into any comprehensive instructional theory in the form of prescriptions for when to use appropriate strategy components for each.

The Component Display Theory and the Elaboration Theory have been (and continue to be) developed to integrate this broad spectrum of concerns by integrating strategy components from diverse theoretical perspectives into "optimal" models of instruction (for different goals and conditions) and by developing useful bases for prescribing when to use each of those models (i.e., for prescribing when each model should "optimize" learning). Although much progress has been made, much work remains to be done by many investigators to help build a complete and comprehensive instructional theory that will indeed prescribe optimal models of instruction for diverse sets of goals, students, content, and institutional constraints.

References

Ausubel, D.P. The Psychology of Meaningful Verbal Learning. New York: Gruene and Stratton, 1963.

Ausubel, D.P. Some psychological aspects of the structure of knowledge. In S. Elam (Ed.), The Structure of Knowledge. Chicago: Rand McNally, 1964.

Craik, F.I.M., and Tulving, E. Depth of processing and the retention of words in episodic memory. Journal of Experimental Psychology: General, 1975, 104, 268-294.

Danserau, D. The development of a learning strategies curriculum. In H.F. O'Neil, Jr., (Ed.), Learning Strategies. New York: Academic Press, 1978.

Gagne, E. Long-term retention of information following learning from prose. Review of Educational Research, 1978, 48, 629-665.

Gagne, R.M. Is educational technology in phase? Educational Technology, 1980, 20(2), 7-14.

Gropper, G.L. Instructional Strategies. Englewood Cliffs, N.J.: Educational Technology Publications, 1974.

Gropper, G.L. A metatheory of instruction: A framework for analyzing and evaluating instructional theories and models. In C.M. Reigeluth (Ed.), Instructional Design Theories and Models: An Overview of Their Current Status, in press.

Landa, L.N. The algo-heuristic theory of instruction. In C.M. Reigeluth (Ed.), Instructional Design Theories and Models: An Overview of Their

Current Status, in press.

Lindsay, P.H., and Norman, D.A. Human Information Processing: An Introduction to Psychology. New York: Academic Press, 1977.

Markle, S.M., and Tiemann, P.W. Really Understanding Concepts: Or in Frumious Pursuit of the Jobberwock, Chicago: Tiemann Assoc., 1969.

Mayer, R.E. Integration of information during problem solving due to a meaningful context of learning. Memory & Cognition, 1976, 4, 603-608.

Mayer, R.E. The sequencing of instruction and the concept of assimilation-to-schema. Instructional Science, 1977, 6, 369-388.

Mayer, R.E. Can advance organizers influence meaningful learning? Review of Educational Research, 1979, 49, 371-383.

Merrill, M.D. Learner Control of Conscious Cognitive Processing (Research Report No. 124). San Diego: Courseware, Inc., 1979.

Merrill, M.D. The Component Display Theory. In C.M. Reigeluth (Ed.), Instructional Design Theories and Models: An Overview of Their Current Status, in press.

Merrill, M.D., Reigeluth, C.M., and Faust, G.W. The instructional quality profile: A curriculum evaluation and design tool. In H.F. O'Neil, Jr. (Ed.), Procedures for Instructional Systems Development, New York: Academic Press, 1979.

Merrill, M.D., and Tennyson, R.D. Teaching Concepts: An Instructional Design Guide. Englewood Cliffs, N.J.: Educational Technology Publications, 197

Merrill, M.D., and Wood, N.D. Instructional Strategies: A Preliminary Taxonomy. Columbus, Ohio: Ohio State University. (ERIC Document Reproduction Service No. SE 018-771).

Merrill, M.D., and Wood, N.D. Rules for Effective Instructional Strategies. (Instructional Design Series) San Diego: Courseware, Inc., 1975.

Norman, D.A. Memory, Knowledge, and the Answering of Questions (Report No. 25). San Diego: Center for Human Information Processing, University of California, 1972.

Reigeluth, C.M. In search of a better way to organize instruction: The elaboration theory. Journal of Instructional Development, 1979, 2(3), 8-15.

Reigeluth, C.M. Toward a Common Knowledge Base: The Evolution of Instructiona Science. (Research Report No. 3). Syracuse: Instructional Design, Development, and Evaluation Program, Syracuse University, in press.

Reigeluth, C.M., Merrill, M.D., and Bunderson, C.V. The structure of subject matter content and its instructional design implications. Instructional Science, 1978, 7, 107-126.

Reigeluth, C.M., Merrill, M.D., Wilson, B.G., and Spiller, R.T. Final Report on the Structural Strategy Diagnostic Profile Project. Submitted to the Navy Personnel Research and Development Center, San Diego, CA, July, 1978. (ERIC Document Reproduction Service, No. ED 175 426).

Reigeluth, C.M., Merrill, M.D., Wilson, B.G., and Spiller, R.T. The elaboration theory of instruction: A model for structuring instruction. Instructional Science, in press.

Reigeluth, C.M., and Rodgers, C.A. The elaboration theory of instruction: Prescriptions for task analysis and design. NSPI Journal, 1980, 19(1), 16-26.

Rigney, J.W. Learning strategies: A theoretical perspective. In H.F. O'Neil, Jr. (Ed.), Learning Strategies. New York: Academic Press, 1978.

Rothkopf, E. Writing to teach and reading to learn: A perspective on the psychology of written instruction. In N.L. Gage (Ed.), The Psychology of Teaching Methods. Chicago: The National Society for the Study of

Education, 1976.

Stein, F.S., Witham, J.K., and Reigeluth, C.M. Relating what is to be learned to what is known: Subsumptive sequencing, coordination, and cognitive strategy activation. (Report No. 2). Syracuse: Instructional Design, Development, & Evaluation Program; Syracuse University; in press.

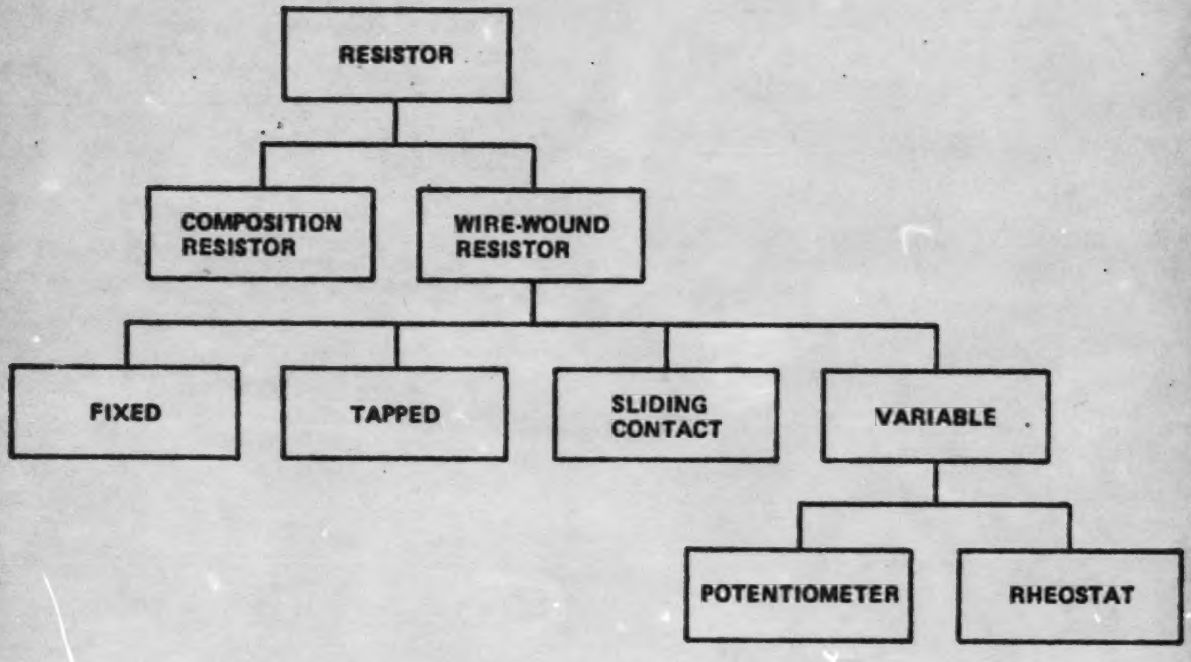
Weinstein, C.E. Elaboration skills as a learning strategy. In H.F. O'Neil, Jr., (Ed.), Learning Strategies. New York: Academic Press, 1978.

Bruner, J.S. The Process of Education. New York: Vintage Books, 1960.

Norman, D.A. Cognitive Organization and Learning (Report No. 37). San Diego: Center for Human Information Processing, University of California, 1973.

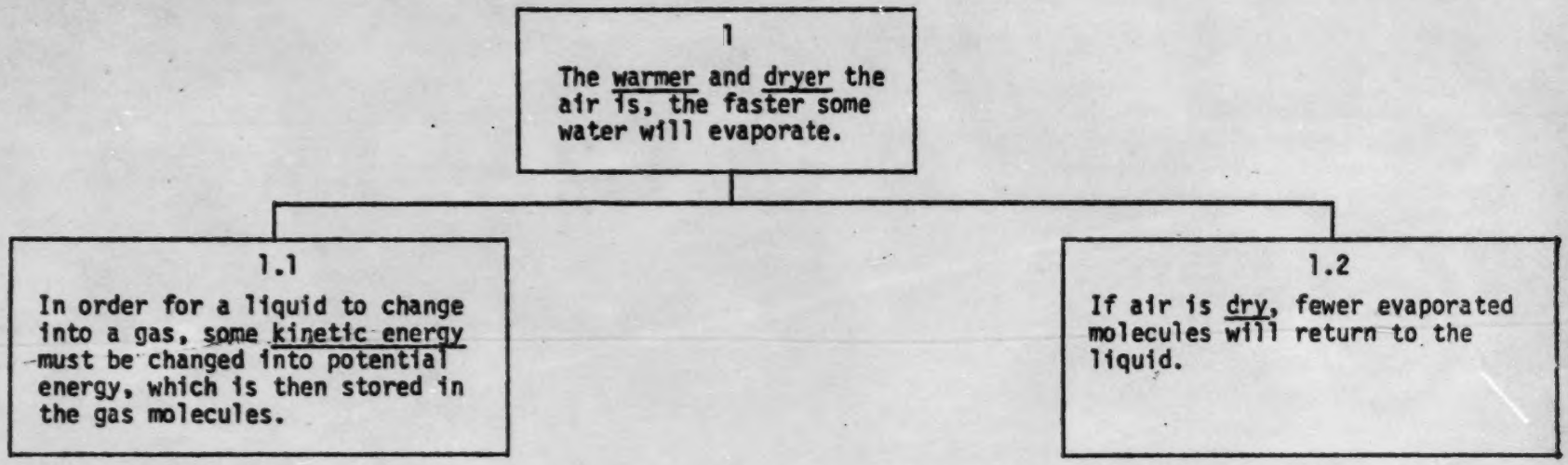
Footnotes

1. A CONCEPT is a set of examples (objects, events, or symbols) that share some common characteristics. To decide if an idea is a concept, ask yourself if one can classify examples as belonging or not belonging to a set.
2. A PRINCIPLE indicates how a change in something is related to a change in something else. It is usually a cause-and-effect relationship that is expressed with the words "if...then...," "explain," "predict," "cause," "effect," "result," "because," "why," etc..
3. A PROCEDURE is an ordered set of actions that are intended to achieve a goal. Synonyms include technique, skill, and method. To decide if an idea is a procedure, (1) see if there is a goal and (2) see if there is an ordered set of operations (physical or mental) for achieving it.



Key: The line between two boxes on different levels means that the lower box is a kind of the higher box.

Figure 1. A Hierarchical conceptual structure which can serve as a synthesizer


1
The warmer and dryer the air is, the faster some water will evaporate.
1.1
In order for a liquid to change into a gas, some kinetic energy must be changed into potential energy, which is then stored in the gas molecules.
1.2
If air is dry, fewer evaporated molecules will return to the liquid.

Principle 1 is superordinate to principles 1.1 and 1.2 because it is more inclusive and more simple than principles 1.1 and 1.2 and it subsumes both of them.

Principle 1.1 is coordinate with principle 1.2 (and vice versa) because both have the same superordinate principle and their examples are mutually exclusive.

Principles 1.1 and 1.2 are both subordinate to principle 1 because principle 1 is superordinate to both of them.

Figure 2. An example of superordinate, coordinate, and subordinate relationships among principles.

	EXAMPLES	NONEXAMPLES	PRACTICE
1.	$3x^2-2$ is a quadratic equation.	3x-2 is not a quadratic equation	Is $3x^2+3x-2$ a quadratic equation?
2.	In the following sentence, "fast" is an adjective: Sally is a <u>fast</u> runner.	In the following sentence "fast" is not an adjective: Sally runs <u>fast</u>.	If there is an adjective in the following sentence, underline it: Sally looks pretty.

Figure 3. Examples of three kinds of instances.